FY-2001 PROPOSED SCOPE-OF-WORK for: **Project #:** 104

Effects of Stage Fluctuations on Young Pikeminnow

Lead Agency: U.S. Fish and Wildlife Service

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Date: 15 May 2000

Category (check one):
x Ongoing project
__ Requested new start
__ Unsolicited project
__ Outside funding

Expected Funding Source:
x Annual funds
__ Capital funds
__ Other (explain)

I. Title of Proposal:

Evaluation of effects of stage fluctuations induced by hydropower operations on overwinter survival of young Colorado pikeminnow.

II. Relationship to Recovery Program/Ranking Factors:

V.B.2 – General Recovery Program Support Action Plan: Conduct appropriate studies to provide needed life history information.

III. Study Background/Rationale:

Overwinter survival during first year of life is a primary factor determining year-class strength of most temperate zone fishes. Overwinter survival of age-0 Colorado pikeminnow in the middle and lower Green River nursery areas ranges from 10 - 60% (Haines et al. 1998). Survival of early life stages has been identified as one of the major data gaps in model development for the draft interim management objectives (Crowl and Bouwes 1997).

Winter flows in the middle Green River nursery area are dominated by releases from Flaming Gorge Dam. The nursery habitats for age-0 fish have been identified as backwaters and other low-velocity areas (U.S. Fish and Wildlife Service 1990). It has been hypothesized that winter operations of Flaming Gorge Dam affect survival of age-0 fish (Carlson and Muth 1989; U.S. Fish and Wildlife Service 1992; Valdez and Cowdell 1996; Haines et al. 1998). However, the effects of fluctuating flows on overwinter survival and backwater habitats have not been demonstrated in the field. One possible mechanism for reduced survival is that fluctuating flows transform nursery habitats into flow-through environments. Nursery habitats provide favorable conditions for survival of young Colorado pikeminnow including:

refugia from current, access to preferred thermal conditions, and a productive environment where prey are likely to be encountered. When discharge fluctuations inundate nursery habitats and transform them into flowing environments these survival advantages are eliminated. Resident fish are flushed into the surrounding system and incur increased risk of injury, predation, and metabolic costs associated with the search for another nursery habitat (Haines et al. 1998). Another effect is that in some backwaters the fish may suffer physical damage from anchor and frazil ice (Valdez 1995).

Previous studies in the nursery areas (Haines and Modde 1996; Haines et al. 1998) have shown that population estimates can be made in 20-mile reaches of river, but that accuracy of overwinter survival estimates is influenced by environmental conditions and fish movement into or out of sample reaches during winter. Obtaining accurate estimates of overwinter survival of age-0 Colorado pikeminnow is critical to understanding the life history of the species, modeling population dynamics, determining the factors affecting survival, and managing winter dam operations to protect the species and its habitat. Mark-recapture population estimation is the best means for estimating abundance of age-0 Colorado pikeminnow because it can account for the influence of environmental factors that may affect capture probabilities. In addition, mark-recapture procedures can be used to estimate rates of immigration and emigration.

We propose to use mark-recapture procedures to estimate over-winter survival, and movement of age-0 Colorado pikeminnow and relate the observed responses to stage fluctuations in the Green River induced by hydropower operations at Flaming Gorge Dam. Demonstration of a cause-and-effect relationship in a large-scale environmental study like this one is complicated by the inability to apply the experimental treatment (fluctuating hydrograph) to multiple experimental units (Green River). The lack of randomization and replication of experimental treatments places special demands on the argument for cause and effect (*sensu* Beyers 1998). Consequently, we propose to evaluate the evidence for or against effects on Colorado pikeminnow of Flaming Gorge Dam-induced fluctuations using a weight-of-evidence approach. This approach will integrate correlative evidence from field investigations as well as experimental evidence from laboratory studies.

IV. Study Goals, Objectives, End Product:

1. Determine if overwinter survival of age-0 Colorado pikeminnow is affected by winter operations of Flaming Gorge Dam.
2. Evaluate the assumptions of overwinter survival estimates and specifically determine how Colorado pikeminnow movements affect these estimates.
3. Determine if backwater habitats are physically affected by fluctuating releases from Flaming Gorge Dam during winter.
4. Evaluate alternative methods for collecting age-0 Colorado pikeminnow in backwater, embayment, eddy, and main-channel shoreline habitats during winter.
5. Determine if winter movements are related to fluctuating releases from Flaming Gorge Dam.

End product: A report that addresses accuracy of population estimates, overwinter survival rates, fish movements, and the effect of fluctuating flows on physical habitat conditions.

V. Study Area: Colorado pikeminnow nursery area in the Middle Green River, RM 320-215.

VI. Study Methods/Approach:

This study evaluates the effects of winter operations of Flaming Gorge Dam on the survival, distribution, and nursery habitats of age-0 Colorado pikeminnow. The study has three components: 1) annually estimating overwinter survival in a 40-mile study reach that encompasses the center of age-0 Colorado pikeminnow distribution and is within the influence of daily flow fluctuations from Flaming Gorge Dam, 2) determining specific habitat changes and accompanying fish movement resulting from flow fluctuations, and 3) developing a bioenergetics model that assists in interpreting the field data and predicts the effects of conditions other than those observed during the study. We propose to call for a specific regime of fluctuating flow releases from the dam for each year of the three-year study. We will compare overwinter survival with the amount of flow fluctuation in each year. If survival is low in the highly fluctuating year but high in the relatively stable year, and if these data are in concordance with other laboratory and field data, we will conclude that reduced survival was caused by discharge fluctuations induced by hydropower operations. Similarly, if movement of age-0 fish increases in the highly fluctuating year and decreases in the stable year, then we will conclude that the cause of apparent mortality is related to fluctuation-induced movement.

The first component of this research will be accomplished by conducting population estimates in autumn and again in spring using capture-recapture methods (Haines and Modde 1996, Haines et al. 1998). Overwinter survival will be estimated by dividing the spring estimate by the autumn estimate. The fish captured in each 5-mile subreach will receive a unique syringe-injected elastomer mark. The 40 mile length of the river sampled for marked fish will allow us to estimate overwinter movement of age-0 fish. Resulting data will be used to evaluate whether or not movement occurs during winter and how this factor influences overwinter survival estimates. Additional evaluation of the mark-recapture methodology will be conducted by quantifying dispersal and habitat use of marked and unmarked fish. A basic assumption of the methodology is that marked fish become uniformly distributed within the population of unmarked fish. We will evaluate this assumption by sampling fish in a variety of habitats (e.g., backwater, shoreline, chute channel) and recording abundance and ratio of marked and unmarked fish in each habitat.

The second portion of this study evaluates the effects of fluctuating flows on specific nursery habitats and the fish found in them. The approach is to select a habitat complex consisting of approximately eight backwaters with a mixture of deep and shallow habitats in close proximity so that they are exposed to similar stage fluctuations. In the first year of the study, we will ask for a series of daily fluctuating flow releases from Flaming Gorge Dam consisting of a 5 day period of daily fluctuating flows followed by a 9 day period of stable flows to produce river stage change at Jensen of 0.10, 0.20, and 0.30 m. These experimental flows can be accommodated under the draft report "*Flow Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam, May 1999*" (Muth et al.). The report recommends that flow variability should be limited to produce no more than a 0.10-m stage change within a day at the USGS gage near Jensen, Utah. Discharge releases that result in stage change of up to 0.30 m will be permitted in order to evaluate the effectiveness of this recommendation (R.T. Muth, pers. comm.). Currently, daily fluctuations of 0.12 m during fall and winter at Jensen are commonplace which suggests that the requested flows should have minimal impact on the tailwater trout fishery below Flaming Gorge Dam. In the second year of the study, we will request stable flows and in the third year we will request a 90-d period of fluctuating flows at a level shown to produce fish movement. Backwaters in the habitat complex will be monitored every 6 h during a 24-h period to describe physical changes (surface area, depth, temperature, velocity, ice thickness, and connectivity) as well as fish movement and distribution patterns. Fish will be sampled with various gear, including seines, small fyke nets, and minnow traps. Colorado pikeminnow captured in each selected backwater will receive a unique elastomer mark. This portion of the study will allow description of effects of fluctuating flows on physical habitat (e.g., changes in area, water depth, velocity, ice cover) and fish responses to these changes. For example, sampling should detect transformation of a backwater to a flow-through habitat and the corresponding movement of fish. The outcome of the interaction between discharge, stage, physical habitat, and fish movement will probably depend on the morphology of backwaters, consequently we intend to include a variety of backwater types. By comparing movement and habitat use during periods of fluctuating flow to those during intervening periods of stable flow we will be able to evaluate the effects of hydropower operations and collect data that may explain results of overwinter survival studies. These studies will be conducted during October through December. The majority of this work will be conducted before and after ice cover develops. Exploratory studies will be conducted to evaluate sampling procedures and ability to observe movement of fish under ice cover.

The third component of the study is construction and application of a bioenergetics model for young Colorado pikeminnow. A critical component of any weight-of-evidence argument for cause and effect is general agreement of field (correlative) and laboratory (experimental) data. Experimental studies provide strong evidence of cause and effect because potential confounding effects can be eliminated. Experimental studies can also describe mechanisms potentially responsible for observed responses in the field. One explanation for why survival may be reduced in a fluctuating environment is that resident fish incur additional energetic costs because they must respond to daily habitat changes. Field observations have shown that when increasing discharge transforms nursery habitats into flowing environments, young Colorado pikeminnow abandon the habitats. It is assumed that when this occurs, the fish actively seek out new nursery habitats. Daily fluctuations produced by Flaming Gorge Dam may cause this phenomenon to occur several times each day. The cumulative effects of the energetic cost of increased activity due to flow fluctuations can be estimated using a fish bioenergetics model (Beyers et al. 1999 a, b). We propose to construct a bioenergetics model for young Colorado pikeminnow using established methods. Laboratory studies will be used to describe the responses of food consumption and metabolism as functions of fish size and water temperature. The resulting relationships will be incorporated into an existing bioenergetics model (Hansen et al. 1997). Investigators at the Larval Fish Laboratory developed a similar model for fathead minnow during 1998, consequently existing equipment and methodologies are available. Computer simulations will be conducted to predict growth or mass loss of fish under winter conditions. Inputs to the model will include: temperature regime based on field measurements, fish size, energy content of food, energy content of Colorado pikeminnow, activity, and duration of exposure to winter conditions. Existing data describing energy content of prey of Colorado pikeminnow during winter are not available. We will probably obtain estimates of these values from published literature. We will also conduct analysis of gut contents of co-occurring non-native species that are approximately the same size as Colorado pikeminnow. These data will provide qualitative description of what Colorado pikeminnow are likely to be eating so that appropriate energy density values can be selected. The importance of activity on the energetic budget of Colorado pikeminnow will be quantified by conducting laboratory studies that describe the rate of movement of fish under winter temperature conditions and then conducting a series of simulations with the bioenergetic model using a range of activity levels. These simulations will quantify the importance of movement induced by stage fluctuations. Spontaneous rate of movement in the absence of water current will be quantified by placing fish in an arena and video taping their movement at 0, 5, and 10 °C. Regression analysis will be conducted to describe the rate of spontaneous activity as a function of water temperature. This rate of movement will be used as a baseline for simulations using the bioenergetic model. Simulations will be conducted using: activity levels ranging up to 4 times the spontaneous rate; a range of fish sizes in fall (sizes based on analysis of existing data); and a temperature regime obtained from backwaters in the Green River during winter. No long-term laboratory studies of growth or survival rates under winter conditions are proposed in this SOW. Short-term (14 days) studies will be conducted to evaluate the accuracy of the bioenergetic model for predicting fish growth based on fish size, food consumption rates, and water temperature. The bioenergetics model will be used to conduct simulations that demonstrate the relative change in growth rates and fish mass as a function of environmental and fish characteristics. Field data are available that describe conditions that allow fish to overwinter (e.g., fish size in autumn, water temperature, growth rates during winter). Results of simulations can be compared to existing data so that a determination can be made about likely effects on survival. For example, field data suggest that young Colorado pikeminnow have positive growth rates during winter, simulations that produce negative growth rates would suggest that conditions for survival are not being met. The model will reveal the cumulative energetic cost of simulated winter conditions which can be translated into fish growth rates or biomass. Predicted growth rates will be compared to those observed in the field during winter. General agreement of predicted and observed growth rates will allow evaluation of the accuracy of the model. The final application of the bioenergetics model will be to explore which environmental factors and which characteristics of fish are most important for assuring winter survival. For example, analysis of the bioenergetics model can rank the relative importance of variables like fish size in autumn, fish activity rates, water temperature, and food availability on fish growth (Beyers et al.1999 a). The resulting analysis will allow fishery managers to evaluate the costs and benefits of alternative management strategies. For example, the bioenergetics analysis may suggest that in years when fish size in autumn is below a specific size, nothing can be done to prevent overwinter mortality. Alternatively, the analysis can identify circumstances when overwinter survival of fish is potentially good, provided that energy is not lost due to increased fish activity caused by operations of Flaming Gorge Dam.

VII. Task description and schedule:

Task 1. Call for the following flow release pattern from Flaming Gorge Dam.

a) Year 2000 - stable flow through winter.
b) Year 2001 - 5 d releases of daily fluctuating flows followed by 9 d stable flows to accomplish the following stage changes at Jensen:0.10 m, 0.20 m, 0.30 m (23-27 October, 0.10 m stage change; 13-17 November, 0.20 m stage change; 18 November-3 December, non-fluctuating flow; 4-8 December, 0.30 m stage change).
c) Year 2002 - 90 d daily fluctuating flows at a level known to move fish (stage determined from data collected year 2001).

Task 2. Estimate population size in a 40-mile reach of nursery habitat in autumn and spring, using capture-recapture methods.

a) Make three sample passes through each reach
b) Give a unique mark to fish captured in each 5-mile subreach using syringe-injected elastomer and combinations of color (four) and location (four).
c) Sample backwaters, embayments, side channels and other seinable habitats and record locations, main channel and habitat temperatures, size, and depth, and numbers of marked and unmarked fish captured.
d) Record location of each recapture.
e) Measure total length and weight of a sample of 100 age-0 Colorado pikeminnow.

Task 3. Monitor selected habitats (backwaters, embayments, eddies, main-channel shorelines) for changes in physical characteristics and fish use during flow fluctuations produced by Task 1.

a) Select a backwater complex consisting of approximately eight backwaters with a range of characteristics (e.g., deep and permanent, or shallow and ephemeral) and containing age-0 Colorado pikeminnow.
b) Map the complex in autumn, using GPS. Install temperature loggers and staff gages in the selected habitats.
c) During the period of daily fluctuating flows, conduct hourly sampling of physical habitat characteristics (e.g., backwater area, depth, ice cover and thickness, and DO, describe connectivity) and otherwise characterize habitat changes.

d) Also on each visit, sample fish with seines, small fyke nets, and minnow traps to determine if young Colorado pikeminnow are present.

Task 4. Conduct laboratory studies to construct a bioenergetics model for young-of-year Colorado pikeminnow and compare model predictions with field observations. Assess model sensitivity to environmental factors and fish characteristics.

Task 5. Write the final report, addressing accuracy of population estimates, overwinter survival rates, fish movements, and the effect of fluctuating flows on physical habitat conditions.

Study Schedule:

Task 1: 2000, 2001, 2002
Task 2: 2000, 2001, 2002
Task 3: 2000, 2001, 2002
Task 4: 2000, 2001, 2002
Task 5: 2002, 30 September 2002

VIII. FY-2001 Work:

1. Deliverables/due dates: annual report 15 Dec 2001

2. Budget

Task 2 (Vernal CRFP)	
Labor	$50.0K
Travel	
Equipment	
Other	5.0K
Total	$55.0K
Task 3 (Vernal CRFP)	
Labor	$17.8K
Travel	
Equipment (nets, temp loggers)	5.0K
Other	
Total	$22.8K
Task 4 (LFL)	
Labor	$14.0K
Travel	0.7K
Equipment	2.7K
Other	2.6K
Total	$20.0K
Grand total	$97.8K

FY-02 Work

1. Deliverables/due dates: final report 30 Sep 02
2. Budget (same as above for tasks 2, 3)

Task 4	
Labor	$ 8.4K
Travel	0.8K
Equipment	0.7K
Other	1.5K
Total	$11.4K

Task 5	
Labor	$ 9.0K
Travel	1.6K
Equipment	
Other	
Total	$10.6K
Grand total	$ 99.8K

IX. Budget Summary:

FY-01 $97.8K
FY-02 $99.8K

*Does not include BR-FWS transfer overhead costs

X. Reviewers:

John Hayse, Richard Valdez, Ed Wick

XI. References

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